# Quantifying multiple benefits of sustainable plus energy neighbourhoods for investment and policy decision-making

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## Abstract
Sustainable plus-energy neighbourhood (SPEN) is an innovative concept of decarbonising the building stock which is being tested within the Horizon 2020 project syn.ikia. The neighbourhood approach considers the interaction of the building with the urban infrastructure. The four syn.ikia demo projects deploy sufficiency design measures, such as shared spaces, assets and services (e.g. RES, HVACs, heat and electricity storage). SPENs aim for high energy efficiency to reduce energy demand and achieve a positive energy balance at the neighbourhood scale. SPENs require additional investments compared to business-as-usual (BAU) projects, however, they also provide multiple added social, economic and environmental benefits. At a societal level, they contribute to lower GHG emissions, leading to lower mortality and morbidity rates. Improved accessibility to public and cycling infrastructure contributes to physical and mental health, as well as inclusion and affordability. At an individual level, improved IEQ yields health and productivity benefits for the dwellers. Such projects rely heavily on public funding; to scale up SPEN to the private residential sector, therefore, there is an increased need to access private funding. The EU Taxonomy and ESG Finance encourage sustainable investments in real estate. Investors, asset managers and policymakers need evidence-based and commonly accepted methodologies to assess ESG aspects of projects. MBx tool, developed within syn.ikia project, is a step forward in quantifying and monetising the social welfare, micro-economic and environmental benefits of projects, by considering the added values of the SPEN approach. This decision-making tool for policymakers and investors uses Social Cost-Benefit Analysis method to compare the benefit-cost ratio and return-on-investment of SPEN against that of BAU. MBx tool can help investors identify ESG investment opportunities and future-proof real estate assets.

## Sustainable and Positive Energy Neighbourhoods: An Introduction
The development of Sustainable Positive Energy Neighbourhoods (SPENs) is strongly aligned with the concept of Positive Energy District (PED) stated by the implementation plan of EU Strategic Energy Technology (SET) Plan Action TWG 3.2. It is inspired by discussions within the European Innovation Partnership on Smart Cities and Communities (EIP-SCC) supported by the European Commission, and especially by the initiative on Positive Energy Blocks and the "Zero Energy/Emission Districts" mentioned in the TWG 3.2 declaration of intent [1]. The SET Plan identified 100 Positive Energy District projects in both existing neighbourhoods and new developments to achieve its goal of planning, deploying and replicating decarbonisation at neighbourhood or district scale by 2025 [2][3].

The *syn.ikia* project defines SPEN as a group of interconnected buildings with associated infrastructure, located within both a confined geographical area and a virtual boundary. The concept is piloted in four neighbourhoods in Spain, Austria, Norway and the Netherlands. A SPEN aims to reduce its direct and indirect energy use towards zero over adopted complete year and an increased use and production of renewable energy according to a normalization factor. Moreover, the SPEN framework includes a strong focus on cost efficiency, indoor environmental quality, occupant satisfaction, social factors (co-use, shared services and infrastructure) and power performance (peak shaving, flexibility, self-consumption).

Urban regeneration through SPENs offers opportunities to accelerate climate change mitigation and adaptation efforts and results in a dynamic policymaking environment [4]. Comprehensive approaches aiming to upgrade not only single buildings but rather a whole neighbourhood in a holistic way are needed to cost-effectively decarbonise the building stock and its energy systems by engaging the communities. They can also be more attractive to investors and policymakers due to distributed risk and project aggregation aspects. Aggregating the demand from various individual building owners in a neighbourhood increases the market chances for those involved in selling or supplying new products and services and enables industrialised processes at high quality and low costs [5]. The 2024 EPBD recast recognises the added value of a district/neighbourhood approach in terms of cost efficiency due to industrial solutions, the integration with the urban infrastructure '***energy, mobility, green infrastructure, waste and water treatment and other aspects of urban planning and may take into account local and regional resources, circularity and sufficiency***'.

#### MULTIPLE BENEFITS OF SPENS

The concept of SPENs presents a new range of benefits, in addition to the benefits of individual energy-efficient buildings. These are often referred to as 'multiple benefits', which usually refers to the many intended or unintended benefits to the stakeholders of policy or project that go beyond their primary objectives. In the context of energy efficiency investments, multiple benefits refer to benefits for residents and society that are beyond energy-related benefits, such as savings in energy and decreased energy expenses. Non-energy related benefits include increased productivity, better health, improved educational outcomes, reduced need for new energy infrastructure, increased property values, employee satisfaction and retention, job creation and economic development. Research and several EU-funded projects [6], [7], [8] have identified, and in some cases quantified and valued (i.e. monetised), several sets of multiple benefits. These projects have consistently shown that the non-energy benefits outweigh the energy benefits. Multiple benefits of energy-efficient buildings are often identified at two levels **1) the individual/private level, or at 2) a wider societal level**. Benefits at the former level include reduced energy costs, improved indoor environmental quality, reduced health costs and are usually relevant to value chain actors at the individual building level, such as building owners and tenants. Benefits at the latter level include reduced outdoor air pollution, reduced public health costs and job creation, which are of particular interest to policymakers, public authorities and urban planners. In addition, beyond financial returns, investors find value in some of the multiple benefits at the societal level, which could influence investment decisions in the context of Environmental, Social and Governance (ESG) investments.

#### KEY STAKEHOLDERS AND BENEFICIARIES OF SPEN MULTIPLE BENEFITS

In order to identify and assess the multiple benefits of SPENs, it is essential to establish a network of stakeholders responsible for regulating policy and public administration to facilitate the creation and just sharing of such assets and others who, invest in, develop and inhabit them [9]. This will ensure a continuous and equitable return on investment in the form of monetary, energy-related, and non-energy-related benefits for all the stakeholders. Key stakeholder groups of SPENs include policymakers, investors, industry and individuals. Policymakers at all levels, including the European Union, national, regional and local governments, facilitate SPENs by setting policy objectives and regulatory frameworks and financial incentives that enable their development. The suitability of neighbourhoods and the willingness of the inhabitants to participate in SPEN projects then becomes crucial. Financing these developments requires investment from both financial (e.g., banks, non-banking financial institutions and institutional investors) and non-financial (e.g., building owners, public authorities, municipalities, NGOs) stakeholders. All of this will provide an enabling environment for real estate and property developers to develop SPEN, either privately or through public-private partnership.

### MAINSTREAMING SPENS THROUGH INNOVATIVE POLICY FRAMEWORKS AND BETTER ACCESS TO FINANCE

#### Promote policy innovation for decarbonising the building stock

The multiple benefits of a neighbourhood approach to decarbonising the building stock have not been sufficiently assessed in the literature, mainly because they are difficult to isolate and quantify, complex to understand, and lack of access to practical tools [4]. This creates a real barrier to policy innovation and comparison of scenarios with different. Policy leaders have shown to be powerful change agents if they have the information and tools to promote policy change. They find it hard to present a case for action if the benefits of policy change are difficult to measure, monitor, verify and communicate [10]. As a result, policies are designed with narrow objectives and silos policies for urban regeneration and energy policies, that overlook a wide range of multiple benefits to the individuals and society by combining these measures. Therefore, multiple benefits of urban regeneration, including large scale building energy renovation, should be quantified and monetised by using specific approaches, such as social cost-benefit analysis, integrated assessment modelling, multi-criteria analysis and life-cycle analysis.

#### Stimulate sustainability investments through EU Taxonomy and ESG finance

Investment decisions must consider environmental, social, and governance (ESG) factors, also known as sustainable finance, to achieve the goals outlined in the European Green Deal, which is driving the EU's ambition for climate neutrality [11]. To this end, the EU Commission has devised a classification system (taxonomy) to identify environmentally sustainable economic activities [12] This scheme was enacted through the EU Taxonomy for sustainable activities, "that defines criteria for economic activities that are aligned with a net zero trajectory by 2050 and the broader environmental goals other than climate" [13]. The Taxonomy covers six environmental objectives: (1) climate change mitigation; (2) climate change adaptation; (3) the sustainable use and protection of water and marine resources; (4) the transition to a circular economy; (5) pollution prevention and control; and (6) the protection and restoration of biodiversity and ecosystems.

The multiple benefits concept fits well with the objectives of the EU Taxonomy and helps as a tool to support the technical screening criteria. The technical criteria set in the Delegated Acts of the Taxonomy are technology-neutral and evidence-based. For example, to qualify as energy-efficient projects, new constructions have a achieve at least 10% lower Primary Energy Demand (PED) than the threshold set for nearly-zero energy buildings. Thus, any methodological advances in quantifying the benefits of sustainable construction and real estate can assist investors and businesses in making informed decisions by increasing transparency through disclosures. The ESG finance, besides environmental aspects, includes also social aspects such as governance and uses other compliance methods such as green building certifications.

#### Support the stakeholder decision making

Energy and environmental policy objectives often have multiple dimensions, such as reducing GHG gas emissions and air pollution. A multiple benefits approach helps stakeholders visualise and quantify these benefits and contextualise them in relation to other measures. A thorough and integrated approach is therefore needed to fully capture the multiple benefits, going beyond individual buildings as in the case of SPENs, which could provide a higher cost-benefit ratio. This should include frameworks, methods and tools for ex-ante quantification of multiple benefits that are tailored to suit the needs of different stakeholders [14]. Policymakers and investors can use such tools and the underlying data to enable them to formulate evidence-based policies, compare scenarios and make targeted investments. The objective criteria for quantifying and monetising multiple benefits help stakeholders such as policymakers, developers and investors to make informed decisions and broaden their horizons with further insight into benefits and returns.

### DECISION MAKING FRAMEWORKS FOR IDENTIFYING AND MONETISING MBS

For any multiple benefits to be considered in policy-related decision making, the outcome must have a direct link to market valuation [14]. In other terms, it should most often monetise the impact on the end-user, investor or other beneficiaries. For example, valuing productivity of employees in terms of financial gains or valuing health benefits as applicable health services costs. Theoretically, for each benefit presented in the previous section a monetary value could be estimated. To do so, the impact of the measure is first quantified in physical units (e.g. life years saved, no. of full-time jobs created, tons of $CO_2$ avoided etc.) before translation into a monetary value. For non-market goods and services, the valuation is typically carried out by estimating the willingness to pay (WTP) for benefits or the willingness to accept (WTA) compensation for losses using frameworks and methods such as avoided costs, choice experiments, replacement costs, contingent valuation, hedonic pricing etc.). However, there have been certain concerns over the use of economic valuation methodologies and commodification of ecosystem and social welfare raising some ethical implications.

While many case studies and research projects have shown the possibility of monetization of multiple benefits, their application is still a challenge for decision-makers in financial evaluations (e.g. investors, policymakers). Previous studies and research were focused generally on economic and environmental impacts [15], while several studies have outlined and quantified social impacts, such as effects on living conditions [16]. In a larger study by Reuter et. al. [17], a set of 20 indicators were identified for the quantification of multiple benefits of energy efficiency divided mainly under economic, environmental, and social categories and the findings form a part of the ODYSSEE-MURE database [18]. Clear methodological frameworks must be developed to strengthen decision-making, given the increasing importance of multiple benefits for the society.

A summary of decision-making frameworks used for the calculation of multiple benefits for different purposes is given in Table 1. To incorporate the multiple benefits into decision-making, there are many frameworks that are used for assessing the multiple impacts such as cost-benefit analysis (CBA) which is generally based on life-cycle cost analysis (LCCA) or net present value (NPV) and uses real-time inflation, discount factors and investments. Approaches based on multiple criteria analysis (MCA) can indeed be used to consider impacts that cannot be monetized. It usually requires a consultation process for results to get legitimacy among the stakeholders. In many cases, different modelling methods are used to complement each other and serve as outputs for MCA.

A more holistic approach is life-cycle assessment (LCA) which also considers analysis of potential environmental loads and resources [19], and has been used in the EERA data project [20]. Economic rate of return (ERR) or internal rate of return (IRR) can also be used for such calculations (similarly to CBA), provided multiple benefits are monetised [21]. There are few holistic decision-making methods that are available for including multiple benefits in their assessments, however, none of them have incorporated multiple benefits at the neighbourhood scale for decision-making.

### WHY IS THE SYN.IKIA FRAMEWORK FOR MULTIPLE BENEFITS OF SPENS NEEDED?

Currently, there is no framework for the identification of multiple benefits of SPENs. The lack of commonly accepted KPIs, definitions and benchmarks is a key barrier to communicate multiple benefits to stakeholders [23]. Existing instruments for measuring building performance, such as Energy Performance Certificates (EPCs) and green building certification systems, may not be fully comprehensive, comparable or linked to the financial performance data of the buildings [23]. Policymakers or other public actors find it difficult to obtain the data and analysis that are needed to clearly demonstrate multiple benefits. Developers, investors and financial institutions see little value in such data unless it is presented in a way that meets their ESG goals and commitments. Currently, there is no framework for the identification of multiple benefits of SPENs. The lack of commonly accepted KPIs, definitions and benchmarks is a key barrier to communicate multiple benefits to stakeholders [23]. Existing instruments for measuring building performance, such as Energy Performance Certificates (EPCs) and green building certification systems, may not be fully comprehensive, comparable or linked to the financial performance data of the buildings [23]. Policymakers or other public actors find it difficult to obtain the data and analysis that are needed to clearly demonstrate multiple benefits. Developers, investors and financial institutions see little value in such data unless it is presented in a way that meets their ESG goals and commitments.

Table 1. A mapping of methods and their use in assessment of multiple benefits with strengths and limitations [22].

| Methods | Climate | Health | Ecosystem | Crops | Energy system | Built environment | Social welfare | Macro-economic* | Resources | Strengths | Limitations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cost-Benefit Analysis** | X | X | X | X | X | X | X | X | X | analytical rigour, express all impacts in single unit, applicable to all environmental impacts and few social ones | Intended for small scale projects, methodological constraints to monetisation, ethical considerations |
| **Life Cycle Assessment** | X | X | X | X | X | X | | | X | assesses upstream and downstream impacts | no theoretical basis for single score, no consideration for economic feedback |
| **Multicriteria Analysis** | X | X | X | X | X | X | X | X | X | wide applicability, can engage stakeholders in process, no monetary evaluation | subjective weighing with limited scientific basis |
| **Computable General Equilibrium models** | | | | | | | | X | | ability to model entire economic impact | market focused and do not account external impacts |
| **Input-Output models** | | | | | | | | X | | focus on entire economy | simplified view of economy |
| **Integrated assessment models** | X | X | X | X | | X | | | X | links between economy and environmental systems | lack of consistent theoretical framework |
| **Macro-econometric models** | | | | | | | | X | | focus on entire economy | too complex and lack comprehensive view |
| **Abatement cost curves** | X | X | X | X | X | X | X | X | X | costs of energy savings and emissions abatement (direct) | no interaction with economic system |

## The syn.ikia framework for the identification of SPEN multiple benefits – The Method

A conceptual framework has been developed to clearly identify multiple benefits of SPENs that are crucial for decision-making. The framework follows these essential steps:

1. **Identification** of the key benefits and the stakeholders who will receive these benefits
2. **Quantification** and **monetisation** of the identified benefits

### IDENTIFICATION OF KEY BENEFITS AND STAKEHOLDERS THROUGH MULTIPLE BENEFITS IMPACT PATHWAY

To identify the multiple benefits of SPENs, syn.ikia prepared a framework with a conceptual impact pathway that explores the added values that would arise from SPENs, the resulting changes and studies their multiple benefits (end-point impacts). Therefore, a conceptual impact pathway map (see Figure 1) has been developed to illustrate the wide range of benefits of SPENs. However, it is possible to construct multiple possible pathways leading to different multiple benefits (end-point impacts). The map illustrates the interrelationships between different key performance indicators (KPIs) of SPENs (i.e. smartness) and their end-point impacts that contribute to environmental protection, economic prosperity and welfare effects for various stakeholders.

For a comprehensive appraisal of the multiple benefits of SPENs, it is crucial to identify the causal relationships and interactions among the added values (technological and non-technological), the resulting changes and their final end-point impacts. However, a more accurate identification of these such end-point impacts (which are also the multiple benefits) could be made by identifying the relevant stakeholders (e.g. homeowners, tenants, developers) who will be affected by an initiative, policy or project. A taxonomy of endpoint impacts has been developed through a review of the literature and expert consultation, although some overlap between the various impacts is inevitable. Therefore, the interrelationships between various end-point impacts must be studied and furthermore, the end-point impacts could be further categorised as social, economic and environmental benefits that are relevant to the assessment of multiple benefits. Depending on the type of stakeholders, project or policy, there may be several different end-point impacts. Furthermore, these end-point impacts could be better identified in the early stages of decision making through the recommended impact pathway. syn.ikia provides an example to create an impact pathway for SPENs through the following steps:

1. Listing the key performance indicators (**KPIs**) of SPENs [24]
2. Identification of **stakeholders** for which the impact pathways should be constructed and **added values** (technological (e.g., renewable technology, fuel switch) and non-technological (e.g., lifestyle, user behaviour)) created by SPENs for them
3. Identification of **changes** (transformation) created by SPENs
4. Multiple benefits (**end-point impacts**) occurring from each of the changes
5. Analysing causal relationship between added values, changes, and end point impacts.

### QUANTIFICATION AND MONETISATION OF THE IDENTIFIED BENEFITS USING SOCIAL COST-BENEFIT ANALYSIS (S-CBA)

As presented in Table 1, there is a wide variety of tools and methods for estimating the macro-economic and environmental benefits of energy efficiency measures including the assessment of public and private costs and their impacts but the estimation of social welfare benefits has been limited which is very relevant for SPENs. Therefore, in this research, the end-point impacts should be identified, quantified and monetised as part of a social cost-benefit analysis (S-CBA) [25]. S-CBA is an application of social welfare economics principles to normative questions around investment choices. It is based on the assessment of changes in welfare benefits and costs, expressing them all in the common currency of monetary values to calculate the net effect on the total economic wellbeing of society. 'The broad purpose of S-CBA is to help social decision-making and to increase social value or, more technically, to improve allocative efficiency' [26]. The welfare effects are changes in health and wellbeing, which, in economic terms, are measured as producer surplus (increase in production profitability) and consumer surplus that results in the expansion of people's consumption possibilities. This includes their access to services, publicly provided non-market goods and also services of the natural environment such as the quality of air and water, access to nature and general amenity infrastructures. S-CBA is an application of social welfare economics principles to normative questions around investment choices. It is based on the assessment of changes in welfare benefits and costs, expressing them all in the common currency of monetary values to calculate the net effect on the total economic wellbeing of society. 'The broad purpose of S-CBA is to help social decision-making and to increase social

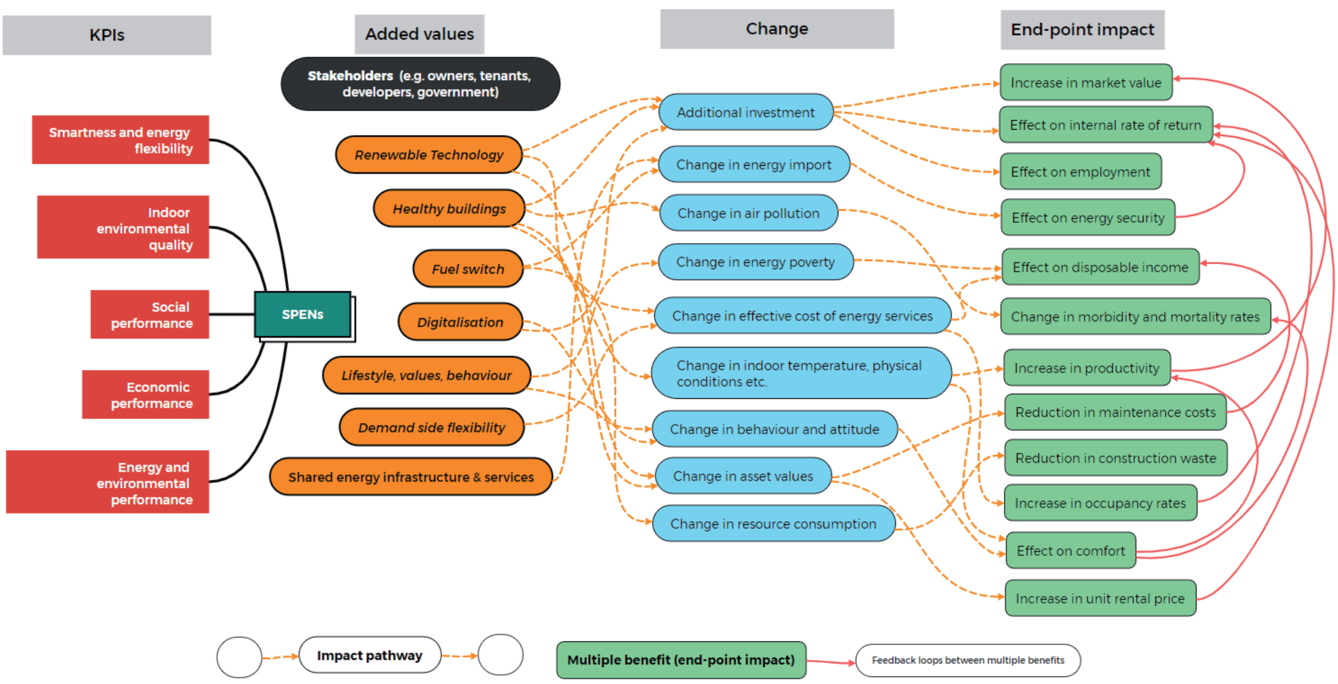


*Figure 1. An example of SPEN impact pathway.*

value or, more technically, to improve allocative efficiency' [26]. The welfare effects are changes in health and wellbeing, which, in economic terms, are measured as producer surplus (increase in production profitability) and consumer surplus that results in the expansion of people's consumption possibilities. This includes their access to services, publicly provided non-market goods and also services of the natural environment such as the quality of air and water, access to nature and general amenity infrastructures. There are two principles that an S-CBA fulfills:

- demonstrating an investment will be worthwhile and deliver benefits of greater value than its costs
- comparing the efficiency of an investment against that of other proposals and ranking them by their benefit-cost ratio (BCR).

  **BCR = PV(B)/PV(i+c)**

Where PV is present value, B is benefits, i is capital investment and c is all other costs.

#### Attaching value to multiple benefits

1. Valuation in S-CBA is based on people's preferences expressed through prices of market goods or inferred through other means for non-market effects. The value of improvements in wellbeing is commonly inferred from the maximum amount of affected individual's willingness to pay (WTP) for an improvement in wellbeing or the minimum amount of individual's willingness to accept (WTA) as compensation for a drop in wellbeing. The sum of these amounts across the community indicates the societal value of gaining the improvement or bearing the drop such as in the case of developing SPENs. Thus, S-CBA is the preferred appraisal tool because it measures costs and benefits as variations in human well-being (i.e., in utility), thus estimating the net contribution of each of the defined project or policy options to the aggregated welfare of the society.
2. The monetary measure of a change in an individual's well-being due to a change in environmental quality is called the total economic value of the change (see Figure 2). The total economic value of a resource can be divided into use values and non-use values; i.e. total economic value = use values + non-use values [27].

   – **Use value:** This refers to the social value people have from actually using a good or potentially using it in the future (e.g. recreational activities, productive activities such as agriculture and forestry, etc.), as well the benefits derived from the goods and services provided by the ecosystem that are used indirectly by an economic agent (e.g. the purification of drinking water filtered by the soil).

   – **Non-use value**: Each individual could be assumed to place a value not only on the well-being produced by the good's existence per se on himself/herself (existence value), but also on the well-being caused to other individuals by the availability of that good, either in the same generation (altruist value) or future generations (bequest value).

   – Due to the size limitations further details on methods applied or used to calculate WTP/WTA for each impact (see Figure 2) are not presented in this paper.

## MBx tool: The Results

#### MULTIPLE BENEFITS OF SPENS INCLUDED IN THE SYN.IKIA MULTIPLE BENEFITS TOOL

Table 2, 3 and 4 list and elaborate on the identified and measurable multiple benefits (endpoint impacts) of SPENs identified using the methodology for inclusion and development of the multiple benefits assessment tool. It provides specific details and descriptions of their approach to quantification and further

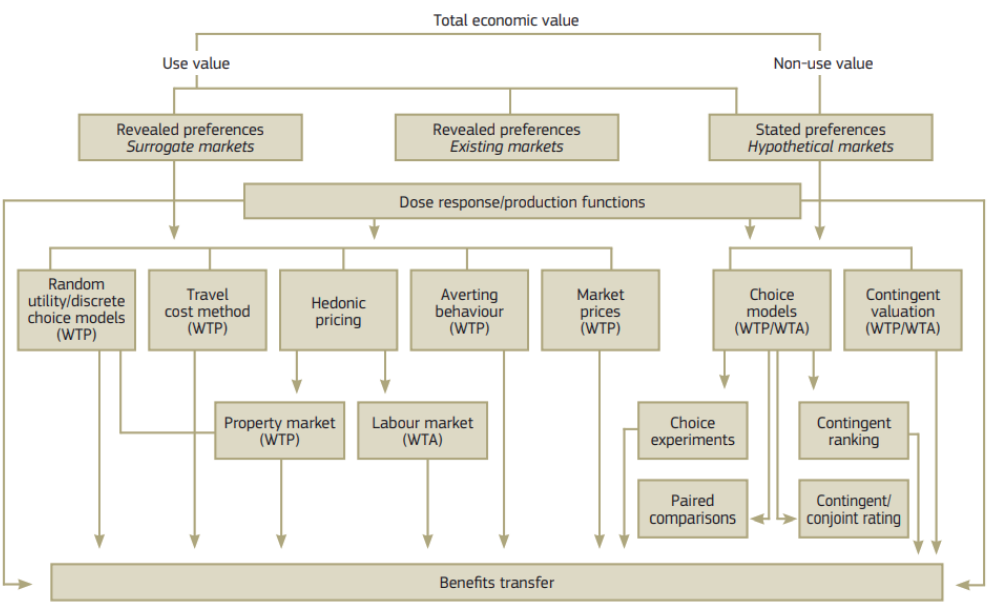


*Figure 2. Main valuation methods [27].*

**Table 2. Social welfare benefits identified in syn.ikia project.**

| Benefit (end-point impact) | Description |
|---|---|
| **Lower associated cost to asthma: Direct costs** | Living in homes with high quality energy efficiency standards, as SPENs, which achieve positive energy buildings levels, could reduce the risk of morbidity, resulting in a lower prevalence of respiratory diseases, like asthma, chronic obstructive pulmonary disease, hypertension, stroke, heart attack and depression. Reducing the prevalence of such morbidities will result in a decrease in the number of patients requiring care from the healthcare system, leading to a reduction in direct healthcare costs – those associated with medical care such as diagnosis, treatment, and rehabilitation. |
| **Lower associated cost to chronic obstructive pulmonary disease (COPD): Direct costs** | |
| **Lower associated cost to hypertension: Direct costs** | |
| **Lower associated cost to stroke: Direct costs** | |
| **Lower associated cost to heart attack (myocardial infarction): Direct costs** | |
| **Lower associated cost to depression: Direct costs** | |
| **Physical health gain from walking** | By promoting alternative modes of transport, such as cycling, and creating neighbourhoods with easy access to essential services and improved walkability, people will be more likely to choose walking and cycling as a mode of transport. Walking and cycling contribute to significant physical health benefits and gain Quality Adjusted Life Years (QALYs) for residents. |
| **Physical health gain from cycling** | |
| **Health loss from air emissions (PM10, $NO_x$, CO, hydrocarbons)** | Air emissions of different particles and gases, like PM10, $NO_x$, CO and hydrocarbons have significant impact on public health. All of these compounds are associated with respiratory problems and some also affect cognitive functions or cause cardiovascular issues. By reducing the negative effects of emissions on health, the ability of individuals to concentrate will be improved and the number of sick days taken can be reduced. In addition, Disability-Adjusted Life Years (DALYs) can be avoided and increased. |
| **Lower inpatient hospital visit** | The average number of consultation visits to a doctor in the EU range from 4 to 7.3 times a year. Around 10% of inpatient hospital visits are due to poor indoor air quality. SPENs can considerably enhance indoor and ambient air quality, lower emissions, and decrease the disease burden, subsequently reducing the number of hospital visits by both inpatients and outpatient. |
| **Lower outpatient hospital visit** | |
| **Lower GP visits – Publicly funded (Government contribution)** | |
| **Lower GP visits – Privately funded (patient co-payment)** | |
| **Lower GP visits – Privately funded** | |
| **Value of a Statistical Life Year (VSL)** | Morbidity and mortality can be estimated based on non-market values such as value of statistical life (VSL) or the value of a life year (VOLY). It can also be estimated using market values such as the average cost associated to treat severe illness, lost productivity or cost of medication etc. Non-market estimates are more suitable for monetisation as there is readily available data compared to market-based values. |
| **Property value increase per additional dB noise reduced (per property)** | Road traffic noise is generally continuous, and long-term exposure can have significant adverse effects. These can be categorised as disruptive impacts, such as sleep disturbance and speech interference, and psychological impacts such as annoyance reaction and other behavioural impacts. SPENs must follow the regulatory requirements, such as provision of buffer strips, barriers, building insulation, alternative road surfaces etc. These measures could enhance the project value and could increase the property values. |
| **Property value increase per additional dB noise reduced (per resident)** | |
| **Increase in disposable income due to energy efficiency (reduction in energy poverty)** | Energy-efficient homes are capable of reducing the annual energy expenditure on one's income. Thus, disposable income increases, reducing stress on household income and reducing energy poverty. |
| **Increased rents (Willingness To Pay (WTP) for energy efficiency)** | SPENs could enhance the quality of buildings and neighbourhoods, while also resulting in higher rental fees for tenants due to their improved energy efficiency. The improved energy efficiency comes at an increased cost (i.e., rent), and the feasibility of renting out such buildings would depend on the willingness to pay (WTP) approach. |
| **Reduction in vacancy costs (resulting in increased rental income from property)** | The vacancy rate tells an investor how much potential rental income is being lost due to the unit sitting empty waiting for a new tenant. On average, 15.8 % of the dwellings across the whole of the EU-28 remained unoccupied. While the project costs and rental units would vary from project to project, it can be assumed that due to SPENs and demand for better and energy-efficient buildings, the vacancy rate will remain low. |
| **House condition: minor problems reduced (maintenance)** | Living in a household with high architectural quality, well well-designed energy system and a common energy management facility can reduce individual maintenance costs compared to standard households. |
| **Increased Discount on insurance premiums** | Property insurance premiums are reduced due to the longevity of the design, products and systems used in SPEN projects and also due to the reduced need for maintenance. For example, average property insurance premiums range around €224 per annum (2022) in Germany. A 10% discount is expected on premiums due to SPENs. |
| **1 hour citizen compliance burden – cost of an individual's time** | SPENs reduce the cost of compliance with/for public authorities/government processes e.g. filling in forms, making applications etc. |

**Table 3. Micro-economic benefits identified in syn.ikia project.**

| Benefit (end-point impact) | Description |
|---|---|
| **Probability to default reduced (better credit record)** | A credit risk or payment default risk is the likelihood of a borrower failing to meet their payment obligations in time in accordance with the contractual terms and therefore risk losing credit worthiness, or money in the form of fines and penalties for late or non-payment. Owners and occupiers of sustainable buildings, which are more energy efficient, environmentally friendly and better designed, are less likely to default on their payments. They also tend to have greater financial security, greater spending flexibility, lower energy costs and a reduced risk of illness. In addition, the energy efficiency improvement investment increased the property's value. As a result, the risk of default is reduced. |
| **Willingness to pay a once off payment to avoid uninterrupted power supply (Peak Period)** | The willingness-to-pay (WTP) approach, together with that of the willingness-to-accept (WTA), can be usefully applied to quantify both the direct benefits and the impacts, negative or positive, of the external effects of the project. The WTP measures the maximum amount people would be willing to pay to gain outcomes that they view as desirable or, alternatively, the maximum amount that people would be willing to pay to avoid outcomes they view as undesirable. SPENs stimulate the micro-economic situation due to the willingness to pay over the BAU for improved energy services, such as uninterrupted power supply, and investment in renewable energy systems by the utilities and the neighbourhoods. |
| **Additional payments to support Utility investments in Renewable Energy (WTP)** | |
| **Additional payments to pay for premiums for renewable energy and improve generation of electricity (WTP)** | |
| **Supervision costs reduced (cost per sqm)** | The requirements for surveillance and inspection in the housing stock are defined in laws, decrees, ordinances, statutes and generally accepted technical rules and standards. SPENs, due to their improved design for safety and longevity, reduce costs related to supervision. |
| **Improved asset value (return on investment)** | Energy efficiency in buildings has an impact on the evaluated market values. Buildings with a certification of high energy efficiency generate a rent about 7 per cent higher than otherwise identical buildings and realize an increase of selling prices by 16 per cent. |
| **Improved rentability (improved revenue)** | SPENs would create better buildings and neighbourhood environment, however, tenants will have to pay increased rents for these buildings due to their increased energy efficiency. The improved energy efficiency has a price premium and the willingness to pay (WTP) method would determine the feasibility of such buildings being rented. |
| **Increase in employment (cost per employee)** | Due to the construction and renovation of buildings in SPENs there will be new jobs that will be created in the construction sector. The energy savings generated by SPENs redirect the spending away from the energy industry to support jobs while feeding it back into the local economy. |
| **Work productivity** | Workforce performance can be defined as the amount of labour input per unit of time. An organization's workforce consists of all its employees. Often, workforce performance gains are estimated by the quantity of labor input, but poor indoor air quality can also affect the quality of work. There are several case studies that demonstrate how indoor air quality and thermal comfort can influence a person's productivity. It has been found that employees have better work performances while working in deep retrofitted buildings compared to non-retrofitted buildings. Performance improvements not only benefit employees, but also employers by increasing labour input efficiency, which will be quantified as Multiple benefits of SPENs. |

refinement of the multiple benefits with a more focused impact. *The underlying principle for their selection is based on the available evidence and data for quantifying the end-point impacts and the transparency of their assumptions or methodologies*[1]. Therefore, a further specification of the most relevant benefits identified for SPENs was conducted. This is based on the level of confidence on the available evidence and the possibility of quantifying them through expert review.

#### EXAMPLES OF QUANTIFICATION AND MONETISATION OF THE BENEFITS

While it is not feasible to elaborate on all the multiple benefits, a few examples are presented to explain the quantification and monetisation process.

1. The impact pathway framework methodology is explained in the forthcoming deliverable "A methodology report on the required calculations for the quantification and monetisation of benefits" and can be accessed from https://www.synikia.eu/resource-types/technical-reports/.

**Benefit 1: Health loss from air emissions (PM10, $NO_x$, CO, Hydrocarbons)**

Emissions of different particles and gases, like PM10, $NO_x$, CO and Hydrocarbons, have significant health effect on the population. These compounds are associated with respiratory diseases, besides that some of them either impair cognitive functions or induce cardiovascular issues [28], [29], [30]. The health loss is calculated based on the avoidance of loss of income due to absence from work as there is data available on average sick leaves per year in the EU [31].

*Avoidance of loss of income due to absence from work*

Even though sick leaves in the EU are often fully paid until a certain number of sick leaves per year, they translate into public expenditure and private sector losses. For calculation of the avoidance of income loss due to absence, this 50 % pay cut is taken into account with the average salary. An average of 12.5 sick leaves are taken by employees in Austria due to illness per year, therefore an assumption of 5.1 sick days is taken associated with diseases being impacted by sick buildings [32]. This, avoidance of loss of income is thus calculated as follows (Table 5):

**Avoidance of loss of income due to absence of work = Reduced number of sick days due to avoidance of associated diseases * Average daily wage of person * 0.5.**

#### Benefit 2: Impact of mode on physical and mental health

The impact relates to people who change mode of transport. This could be people who switch private vehicle to walking or cycling, therefore becoming more active. Therefore, the physical health benefits are included in benefit values for assessing pedestrian and cycling facilities.

*Walking benefits*

When a SPEN improves/provides a site (e.g. a dedicated pathway) for safe walking, a health benefit may be ascribed to the pedestrians using the infrastructure. The benefit is irrespective of the length of improvement. It is calculated using the average pedestrian trip length of 1 km times the value in Table 6. The annual benefit calculated for each new individual pedestrian cannot exceed the maximum annual benefit as shown in Table 6 [33].

*Cycling benefits*

For new cyclists using conventional and electric-assisted cycling. Where new SPEN eliminates or improves a site that is an impediment to safe cycling, a benefit of €0.98 per kilometre (for regular bikes) and €0.22 per kilometre (for e-bikes) may be ascribed to the cyclists using the facility [34]. The benefit is irrespective of the length of the improvement. An average of 6 km of cycling per resident can be assumed [35]. The annual benefit calculated for each new cyclist cannot exceed the maximum annual benefit, which is the total estimated economic health benefit for converting an inactive person to an active person using cycling. For new cyclists using conventional and electric-assisted cycling. Where new SPEN eliminates or improves a site that is an impediment to safe cycling, a benefit of €0.98 per kilometre (for regular bikes) and €0.22 per kilometre (for e-bikes) may be ascribed to the cyclists using the facility [34]. The benefit is irrespective of the length of the improvement. An average of 6 km of cycling per resident can be assumed [35]. The annual benefit calculated for each new cyclist cannot exceed the maximum annual benefit, which is the total estimated economic health benefit for converting an inactive person to an active person using cycling. An example assumes (Table 7):

- An average two-way distance cycled per user: 6 km.
- Cycling specific number of days per week for 52 weeks per year.

**Table 4. Environmental benefits identified in syn.ikia project.**

| Benefit (end-point impact) | Description |
|---|---|
| **Energy savings (only renovation)** | Through higher building standards energy is saved and tenants/ owners have lower energy costs. On the other hand, energy suppliers and the state earn less through selling energy and respective taxes. But less energy consumption leads to less emissions and costs for society for climate adaption and mitigation measures. |
| **Energy savings (new renovation)** | |
| **Heat recovery** | By using heat recovery measures in ventilation and sewage systems, heat can be "reused" that would otherwise leave the building into the environment or the water infrastructure. Thereby, energy and emissions and the respective emissions are saved. |
| **Waste-water heat reused** | |
| **Direct GHG emissions saved** | Saving energy in buildings leads to less energy demand/consumption and therefore less direct emissions into the environment. The costs associated with the emission volume can thus be reduced. |
| **Increase in access to open space – per person** | Open space should be provided until the sum of the marginal willingness to pay of all the inhabitants of a neighbourhood is equal to the market value of residential land in the neighbourhood. |

**Table 5. Parameters in calculation of avoidance of loss of income.**

| Parameter | Value |
|---|---|
| **Number of sick days avoided per person due to associated diseases from sick buildings** | 5.1 |
| **Average daily salary (Austria)** | €126.1 |

**Table 6. Health benefit per pedestrian and maximum annual benefit.**

| Benefit | Health benefit for new/ existing users (1h/week) | Maximum annual benefit per new/ existing user |
|---|---|---|
| **Pedestrian** | €120.00 | €6,240 (for 52 weeks) |

Table 7. Cycling health benefits.

| Days cycled/week | Annual health benefits |
|---|---|
| 1 | €305 |
| 2 | €611 |
| 3 | €917 |

- €0.98 per kilometre (for regular bikes) and €0.22 per kilometre (for e-bikes) with €917/user/year health benefit cap.

#### THE MBX TOOL

The multiple benefits that have been identified and monetised will be translated into a decision support tool for investors and policymakers by the syn.ikia developed MBx tool. This tool will take the form of a web-based calculation tool that will help stakeholders to:

- take a consistent approach across the public and private sectors to cost-benefit analysis, including common values and assumptions
- take a long-term and broad view of the societal impacts, costs and benefits of SPENs
- rigorously assess these by monetizing and discounting impacts, where possible, and
- be transparent about the assumptions and data used.

The Underlying structure of MBx tool is shown in Figure 3 following the details of each component.

**Cost inputs**: Here the user is required to input summary operating and capital costs of the initiative. These costs need to be calculated outside of the MBx Tool. **Primary inputs**: A number of primary inputs that drive the calculation of multiple benefit impacts, including the intervention beneficiaries across years and the time period. The MBx tool includes up to 50 years. It also contains the discount assumptions applied to all impact calculations. The information input here is used as a basis for calculating multiple benefit impacts, and discounting these impacts for calculating net present values for each impact. **Impact database**: The database contains a number of calculated values to help in monetising multiple benefit impacts and to do return-on-investment (RoI) analysis. These are the impact values derived using the quantification and monetisation methodology presented in the previous sections. The values are primarily sourced from literature, databases and own calculations. **Impact inputs**: For each multiple benefit impact selected by the user from the impact database, the impact values and also any assumptions about the impact on the beneficiaries are specified for the tool to calculate the impact. **Output summary**: Here the output summary of the calculations based on the impacts and assumptions selected by the user is displayed. The main outputs include return-on-investment (ROI) and benefit-cost ratio (BCR). **Sensitivity analysis**: This allows the user to easily capture results when they run the S-CBA under different assumptions and scenarios and make comparisons between them.

## Conclusions and limitations

SPEN projects contribute to a climate-neutral building stock while offering multiple benefits for the community and society as well as for individuals, such as improved comfort and public health, social inclusion, climate resilience and value retention. To achieve these more ambitious social, energy and environmental targets, SPEN projects often require additional upfront investments compared to BAU. To scale up SPEN to the private residential sector, there is an increased need to access private funding, by incorporating externalities in the cost-benefit analysis. The EU Taxonomy and ESG Finance encourage sustainable investments in construction and real estate. Investors, asset managers and policymakers need evidence-based and commonly accepted methodologies to assess social and environmental aspects of projects. The MBx tool, with the innovative approach of quantifying multiple benefits of SPEN, using S-CBA method, is an important step in assisting investors and policymakers in decision making.

However, there are certain limitations of monetising and adding all non-energy multiple benefits:

- It is not feasible to identify all the multiple benefits as there are limited models to quantify them and lack evidence in research.
- It is not possible to segregate each multiple benefit and some of them inevitably overlap with each other.
- It may be the case that one benefit is the outcome of the other (e.g. reduced air pollution and improved health), and therefore some benefits may be double-counted.

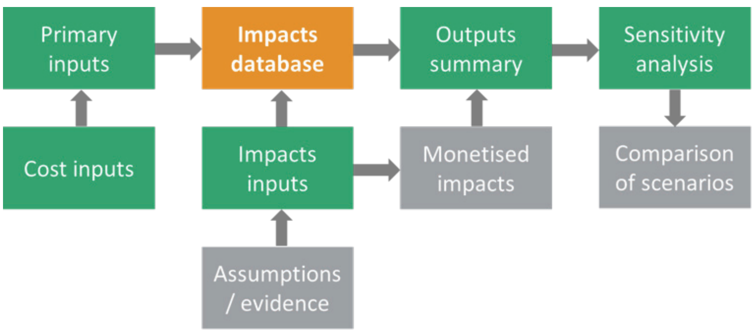


*Figure 3. Underlying structure of SPEN multiple benefits tool.*

- Monetising certain quantified benefits (such as value of life) is difficult and extremely controversial. Alternative tools may quantify impacts on the number of lives for example. However, we decided to quantify all the outputs for an integrated S-CBA analysis to provide a tool for investment decisions.
- Multiple benefits are universal, but their values deviate in different cases.

This research makes a novel contribution and is a first step towards quantifying and monetising multiple benefits at the neighbourhood level. Future research is required to overcome some of the highlighted limitations to increase trust, transparency and value in monetising these multiple benefits by the respective stakeholders.

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